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INCREASED BONE MINERAL DENSITY IS ASSOCIATED WITH HIGHER DYNAMIC JOINT LOADS AT THE ASYMPTOMATIC KNEES OF SUBJECTS WITH UNILATERAL HIP OA

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Purpose: We have previously shown that subjects with endstage *unilateral* hip osteoarthritis (OA) more commonly develop endstage OA of the *contralateral* knee rather than the ipsilateral knee, and that these subjects have higher dynamic joint loads at the contralateral knee than the ipsilateral knee. Local bone mineral density (BMD) reflects the loading history of that bone; hence, BMD may be a marker of excessive loading of the knee joint as well as of early asymptomatic OA. Here, we evaluated subjects who had unilateral hip OA but who were asymptomatic at their knees, to test the hypothesis that asymmetric loading of the knees induced by unilateral hip OA results in elevated BMD at the medial tibial plateau of the contralateral knee compared with the ipsilateral knee, and that these BMD asymmetries correlate with dynamic joint loading at the knees.
Methods: Fifty subjects with symptomatic unilateral hip OA and asymptomatic knees were evaluated. Subjects had moderate to severe radiographic unilateral hip OA using the Kellgren Lawrence (KL) grading system. Subjects were asymptomatic at the knees (WOMAC pain during walking $<$20 mm out of 100 mm). Subjects underwent DXA scanning of bilateral knees and these scans were evaluated in a blinded manner by a trained investigator using a previously validated method. The BMD of the medial and lateral regions of the tibial plateau and the distal tibial shaft were measured in each knee. Subjects also underwent gait analyses using an optoelectronic camera system and multicomponent force plate. Inverse dynamics were used to calculate dynamic joint loads and the peak external knee adduction moment, a validated marker of medial compartment knee loading, was used as the primary load parameter. Paired t-tests were used to evaluate differences in BMD and loading between the knees and Spearman correlations were used to evaluate correlations between BMD and loading. $p<0.05$ was considered significant.
Results: Bone mineral density was significantly increased at the contralateral medial tibial plateau compared with the ipsilateral medial tibial plateau (0.912g/cm$^2\pm$0.208 vs 0.869g/cm$^2\pm$0.196 p=0.040). Furthermore, a direct correlation was found between the medial knee load (peak external knee adduction moment) and BMD at the contralateral medial knee (rho=0.381, p=0.008). No significant differences were noted for BMD at the lateral compartments of the two knees.
Conclusions: This study demonstrates that unilateral hip OA is associated with increased BMD at the contralateral medial knee when compared with the ipsilateral medial knee, that BMD alterations are directly correlated with loading alterations at the OA-predisposed knee (contralateral knee), and that these events occur even in asymptomatic, clinically uninvolved knees. These findings suggest that BMD alterations may be a surrogate marker for joint loading and OA progression, even in asymptomatic subjects. Although further investigation is necessary to delineate causal relationships, BMD may be a useful tool to follow structural progression in longitudinal OA studies.

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ANKLE CONTACT MECHANICS FOLLOWING FOCAL DEFECT RESURFACING WITH A METALLIC IMPLANT: A COMPUTATIONAL INVESTIGATION

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Purpose: A persistent osteochondral defect (OCD) can lead to chronic degeneration of adjacent/opposing cartilage. Focal resurfacing with a metal implant is a promising new treatment option. The superior talar dome is a common site for an OCD, but the dome's geometric complexity presents challenges to successful implant design, selection, and placement. The purpose of this study was to document the effect of implantation parameters upon ankle contact mechanics after focal resurfacing of the talar dome with a metal implant.
Methods: Finite element (FE) simulations of loading of the intact ankle, the ankle after introduction of a 15 mm cylindrical defect to the medial edge of the talar dome, and the ankle with a focal resurfacing implant (HemiCAP; Arthrosurface Inc.) were performed. The ankle contact FE modeling built upon previous work, with bone and the resurfacing implant both treated as rigid bodies, and cartilage as a linear elastic material. A 300 N axial load was applied across the ankle joint. Then the tibia was rotated (under load) about the talus through a functional arc of flexion/extension, with the talus free to rotate. The effects of various implantation parameters (implant height, rotation about its post axis, and valgus/varus tilt) were studied over a simulated motion cycle.
Complementary static loading experiments had previously been performed in cadaver ankles (n=7), before and after creation of a comparable OCD, in part to validate the FE model. Contact stresses were measured using a high-resolution pressure sensor (TekScan). The defect was then resurfaced with a metallic implant, with implantation height controlled in very fine (0.25 mm) increments. Contact stress measurements were repeated at heights from -0.5 to +0.5 mm with respect to an as-implanted reference.
Results: Experimentally there was a 20% reduction in the ankle contact area with the untreated defect, and a 40% increase in peak contact stress, plus a pronounced shift in the highest-loaded region. Following flush implant resurfacing, contact area recovered to 90% of intact, but peak contact stress remained elevated. For 0.25 mm proud implantation, there was a 120% elevation in peak contact stress atop the metal cap, relative to the intact state. FE-computed contact stresses and trends agreed closely with experiments.

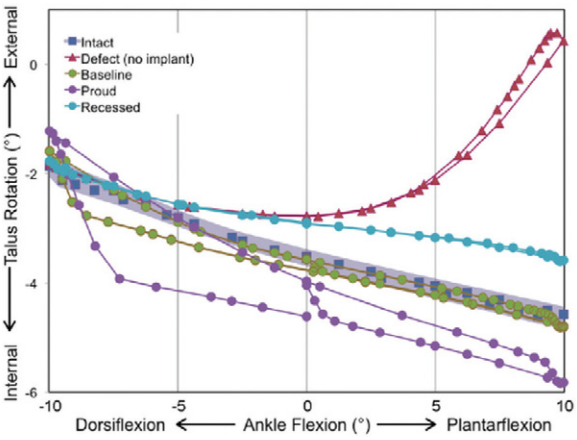

Figure 1. Coupled talar internal roation associated with plantarflexion of the ankle was greatly disrupted when an unfilled talar OCD was modeled. An appropriately positioned focal resurfacing impalnt restored the normal talar kinematics.